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L. O. HOWARD, Entomologist and Chief of Bureau.

INSECTS INJURIOUS TO MUSHROOMS.

BY

C. H. POPENOE,
Entomological Assistant.

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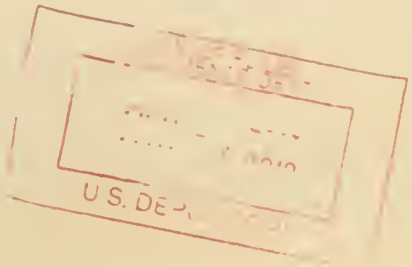

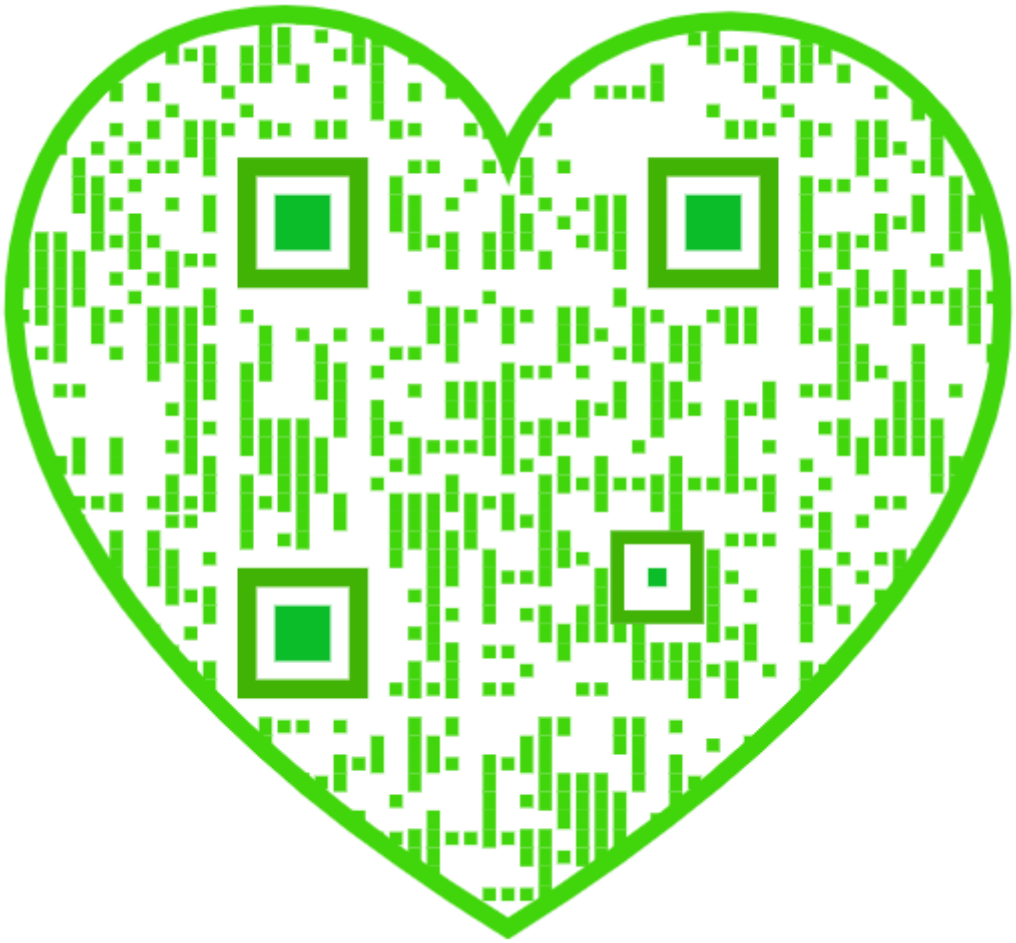

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

INSECTS INJURIOUS TO MUSHROOMS.

By C. H. POPENOE,
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Cultivated mushrooms, especially during warm weather, are attacked by several species of insect pests which frequently destroy an entire crop, or so curtail the production as to make the industry unprofitable. Although this injury is at times serious, little interest has been taken by entomologists in the matter of its control, so that there is practically no available economic literature on the subject. This circular is of a preliminary nature, as the investigation of all insects injurious to mushrooms may not be completed for some time.

FIG. 1.—A mushroom fly, *Aphiochaeta albihalteris*. Male. Much enlarged. (Original.)

The insects which usually attack cultivated mushrooms, and those of which complaints are most frequently made, may be divided roughly into four classes, namely, mushroom maggots, mites, springtails, and sowbugs. Of these the maggots are the most generally injurious, the mites follow in order of importance, owing to the difficulty with which their eradication is accomplished, and then come springtails and sowbugs in the order named.

MUSHROOM MAGGOTS.

(*Sciara multiseta* Felt et al.)

The injurious forms commonly known as "mushroom maggots" are small whitish or yellowish-white maggots usually having black heads.

They are the young of certain small flies or "gnats," two-winged and mostly black in color, of several species belonging to the families Mycetophilidæ and Phoridæ, and to the genera Sciara and Aphiochæta. Of these the species belonging to the genus Sciara are by far the most common and injurious of mushroom pests. They are minute in size, measuring about three thirty-seconds of an inch in length and about one-eighth inch in spread of wings. They are smoky or dusty black in color. The species attracting most attention as pests are *Sciara multiseta* Felt and *Sciara agraria* Felt. Both species are, like the other mushroom gnats, rapid and prolific breeders, especially during warm weather, frequently occurring in mushroom houses so abundantly as to darken the windows. They may be readily confused, however, with gnats of the same genus which breed in manure or in greenhouse soil, and determinations should always be made by a specialist.

Another common species, *Aphiochæta albidihalteris* Felt (fig. 1), superficially resembles the preceding, and has much the same habits, but as yet has not appeared to cause so much damage as have the species before mentioned.

The life history of one of the mushroom maggots is about as follows: The eggs, of which each female is capable of laying nearly 1,000, are generally deposited at the juncture of the stem and cap of the mushroom, or in the manure or soil at its base. In a warm temperature they may hatch within three days, but in colder weather this time may be considerably extended. Upon hatching the larvæ bore at once into the stem or cap of the mushroom, soon riddling the cap, and causing the breaking down of the mushroom in a short time. On account of the perishable nature of their host they pass through their transformations quickly, the larvæ feeding for from 7 to 10 days, by which time the entire cap is destroyed. The larvæ then enter the ground, each spinning a slight silken cocoon just beneath the surface, and pupating. The pupa stage lasts from four to seven days, after which the insects emerge as adults, soon afterwards pairing and ovipositing for the next generation. Owing to the immense number of eggs deposited and to the short life-cycle the rapidity of their increase is remarkable, so that the presence of only a few insects in the mushroom house at the beginning of the season may result in the presence of millions after the beginning of warm weather, thus effectually preventing the cultivation of mushrooms.

CONTROL.

It is evident that in the control of the mushroom maggots measures should be undertaken early in the season for their elimination from the mushroom house and precautions observed against their subse-

quent entrance. These should begin with the construction of the house or cellar. The building should be so constructed as to permit of effective fumigation and should be fitted with tight screens of fine wire gauze, suitable to prevent the ingress of the fungus gnats. The gnats may also be brought into the house through the agency of the manure used in the compost beds, so that it is well to disinfect or sterilize this substance by means of steam. This may be accomplished by placing the manure or soil in vats or boxes, through which steam pipes, perforated to allow the escape of the steam into the boxes, are conducted. (See fig. 2.) The manure should be heated to a temperature of 150° F., which will destroy all animal life occurring therein, without injury to its capacity for producing mushrooms. Fumigation with bisulphid of carbon just previous to planting the mushrooms is also productive of good results in destroying maggots in the compost. The bisulphid should be used at a strength of 2 to 4 pounds to 1,000 cubic feet of space and should be evaporated in shallow pans placed in the highest part of the house. It is very inflammable and even explosive when brought into contact with fire or sparks, so that care should be used to avoid bringing any fire into the building during the process of fumigation.

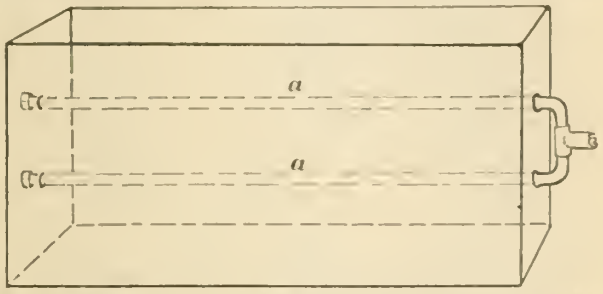

FIG. 2.—Steaming box, or sterilizer, for the treatment of compost. (Original.)

One of the best methods for the destruction of the adults or flies in their occurrence in mushroom houses is fumigation with tobacco or nicotine fumigants such as are used in greenhouses. These should be used in accordance with the directions indicated on the package for a medium or heavy fumigation.[1] Used in this manner, and applied once a week during the bearing season of the mushroom bed, this method has been so successful in reducing the number of flies that very little damage, if any, resulted from the larvæ.

Fumigation with pyrethrum or dusting the powder over the beds is also effective against the mushroom maggots if taken in time, but tobacco fumigation may be considered standard for this use.

[1] The proportion of nicotine in the several preparations varies to such an extent that no standard dose has as yet been formulated.

THE MUSHROOM MITE.

(*Tyroglyphus lintneri* Osb.)

The mushroom mite (*Tyroglyphus lintneri* Osb.) (fig. 3) is a minute, soft-bodied mite, smooth skinned, and white or whitish in color. It is closely allied to the common cheese mite (*Tyroglyphus siro* L.) and resembles that species in appearance. It is, if anything, more prolific than the cheese mite, becoming at times so abundant in mushroom beds as to cover the surface of the compost, and when present in such numbers is extremely destructive, feeding upon the mushrooms in all stages and penetrating the beds and destroying the mycelium. Indeed, in one case observed by Mr. August Busck, of this bureau,[1] the mycelium was destroyed as fast as it grew from the spawn.

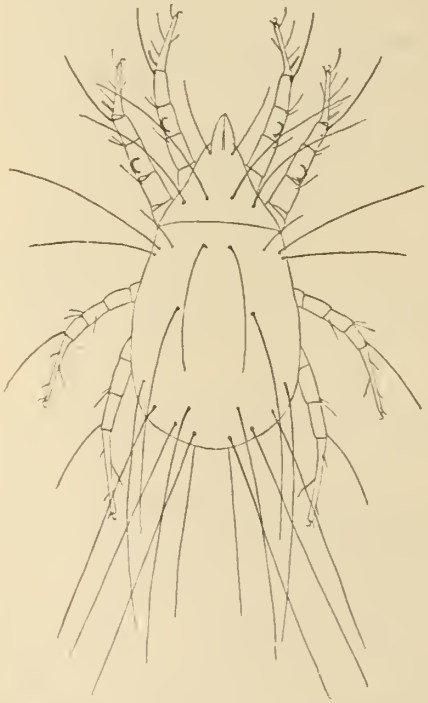

FIG. 3.—The mushroom mite (*Tyroglyphus lintneri*). Highly magnified. (From Banks.)

This species is undoubtedly the cause in many cases of the failure of the spawn to grow, which is likely to be attributed to poor or weak spawn, or to defective cultural conditions. The minute size of the mites causes their presence to be little suspected, and the failure of the spawn to produce mycelium is not understood. Even under conditions favorable to the growth of the mycelium it is possible for the mites to increase to such an extent that the entire bed may be killed out.

Besides the injury to the mycelium, mushroom mites cause damage to the fruiting bodies by eating into them, distorting or destroying the young growth. In the more mature mushrooms the mites may be found clustered in groups consisting of individuals of many sizes, usually hidden in the folds between the gills, where they burrow into the tissue and rapidly break down the caps.

No direct observations bearing on the life history of this species have been made, but judging from that of related species it is about as follows: The eggs, which are large in proportion to the size of the mites, are laid in or about the mycelium of the mushroom, or on the

[1] Bul. 38, Bur. Ent., U. S. Dept. Agr., p. 32, 1904.

young or developing caps. They hatch in a short time into the characteristic six-legged young, which rapidly mature to adults similar to the one in figure 2. The time from the deposition of the egg to the maturity of the mite has not, to the writer's knowledge, been accurately worked out, but undoubtedly occupies only a few days. It is on this account that the mite is able to increase so rapidly, apparently as if by magic, and thus give rise to the theory of spontaneous generation sometimes advanced to explain this condition.

Under certain conditions the hypopus or migratory stage is produced. This stage, according to Banks,[1] is peculiar to the family Tyroglyphidæ, to which this mite belongs, and is quite remarkable. The mite develops a hard, chitinous covering, has no mouthparts, and is provided with short legs insufficient for walking. On the ventral surface of the body is an area provided with sucking disks, by means of which the hypopus attaches itself to an insect and is so transported to suitable breeding grounds in other localities. On arrival at a suitable breeding place the mite detaches itself from its insect host, molts, and soon becomes adult. During the hypopus stage the mite takes no food and causes no injury to the insect which carries it. This peculiar stage is the natural means for the distribution of the mite to new localities, and is in many cases responsible for its appearance in localities far from previously infested beds.

In addition to the way mentioned above, the mite may obtain access to mushroom houses in infested compost or in spawn from infested houses. However, the greater part of the infestation probably takes place through the agency of the small flies which frequent mushroom houses and which carry the hypopus stage of the mite from one house to another.

REMEDIES.

Little can be recommended for the control of the mushroom mite after it has once become established in a house. Owing to the absence of breathing-pores it is little affected by the fumigants suitable for the control of the other mushroom pests, while applications of sulphur, tobacco dust, and other suitable insecticides to the beds seem only to prove slightly inconvenient to the mite. It is one of the most stubborn pests with which we have to deal in mushroom culture, and may be brought into the house in almost any manure that is used for the bed. When in the hypopus stage it is capable of prolonged suspension of vitality and is likely to remain in the house for an unlimited time without death. The only measures, therefore, that may be considered are those of prevention.

When a house becomes infested, all compost should be gathered with the utmost care, removed to the outside, and thoroughly disin-

[1] Proc. U. S. Nat. Mus., vol. 28, p. 79, 1904.

fected by drenching with boiling water, or it may be hauled to a distance and spread upon the ground as fertilizer, or it may be destroyed by burning. The ground occupied by the mushroom beds should be thoroughly scalded, and the woodwork of the mushroom house treated to a wash of creosote or crude carbolic acid, either of which is distasteful to the mites. After complete disinfection has been accomplished the house should be screened, to guard against subsequent introduction of the pest by means of flies. All manure forming the beds should be steamed, according to the directions under the head of mushroom maggots. Care should be used to purchase spawn only from uninfested houses. With these precautions it is unlikely that trouble will be experienced from the attacks of the mushroom mite. Close watch should be kept, however, for any signs of the presence of the mites in the beds, and the compost destroyed upon their first appearance, as it is impossible to secure good results with mushrooms when infested by these mites. All applications of sufficient strength to destroy the mites are likewise injurious to the mushrooms, and it is futile to attempt to control by any artificial means, once the mushroom bed becomes infested, as the mites are buried so deeply in the compost that no insecticide will reach them.

FIG. 4.—A common injurious springtail, *Achorutes armatum*. Much enlarged. (Original.)

A predaceous mite belonging to the Gamasidæ frequently occurs in beds infested by the mushroom mite, feeding upon the latter, and at times becoming so numerous as entirely to wipe out the pest. The gamasid may be known by its longer legs and its manner of running swiftly over the compost or the mushrooms. The writer has seen cases where the gamasid has occurred in such abundance as greatly to outnumber its host. This predaceous enemy does not feed on the mushrooms after the destruction of the mites, but seeks other feeding grounds, or dies by starvation.

SPRINGTAILS.

(*Achorutes armatum* Nicolet et al.)

At times the surface of a mushroom bed becomes alive with minute brown or black insects, which, when disturbed, leap about like fleas in an extremely erratic manner. These are known as springtails, since the springing is performed by the aid of two short bristles situated on the anal segment of the abdomen. These insects (*Achorutes armatum*, see fig. 4) are present in almost all manure, where they feed on the decaying vegetation present, but on occasion they may become quite injurious in mushroom houses. A correspondent

in St. Louis, Mo., reported that in one of his mushroom houses a bed 150 feet in length had been completely destroyed by these pests, which attacked the mushrooms as fast as they appeared, honeycombing them and rendering them unfit for use. The method of attack of this insect is to feed upon the fruiting bodies of the mushrooms, destroying both the gills and the cap. Hundreds may be found clustered upon a single mushroom and eating large cavities in the gills. It appears to be a habit of these insects to congregate in large numbers on caps which have been slightly injured, in which case they rapidly destroy mushrooms which would be readily salable if the injury were not continued. When they occur in large numbers they are likely to attack even the perfect mushrooms, in aggravated cases destroying whole beds.

Insects of this group pass through no larval transformation, the form of the newly hatched young being similar to that of the adult. They are thus likely to be injurious in the same manner throughout their life history.

REMEDIES.

The remedial measures applicable to the control of springtails are to a large extent preventive, as these insects are somewhat difficult to control when once established in a mushroom bed. They are quite resistant to tobacco powders, but applications of buhach or pyrethrum to the beds are productive of some good. As they usually congregate near the surface of the beds fumigation with hydrocyanic-acid gas, according to the directions given in Circular 37 of this bureau, will prove effective in reducing their numbers. The cyanid should be used at a strength of from 3 to 6 ounces to each 1,000 cubic feet of air space, which will not prove injurious to the mycelium.

By way of prevention, steaming all manure, as previously suggested for other species, will destroy springtails equally well. Where possible, it is better to grow the mushrooms at a temperature of about 55° F. than higher, as at low temperatures the springtails breed much less quickly. Dusting the tops of the beds with powdered lime is also said to discourage attack by springtails.

SOWBUGS.

(*Armadillidium* spp. and *Porcellio* spp.)

Considerable injury is often accomplished to mushroom beds through the attacks of oval, grayish, or slate-colored creatures bearing seven pairs of legs. These creatures are not true insects, although known variously by the terms "woodlice," sowbugs, and "pillbugs." Two species, the greenhouse pillbug (*Armadillidium vulgare* La-

treille) and the dooryard sowbug (*Porcellio lævis* Koch), are illustrated in figures 5, 6, and 7.

Sowbugs live in damp, dark places, such as beneath boards, in cellars, and in the cracks of sidewalks. When disturbed many species roll up to form a ball, lying quite still until the danger is past. (See fig. 5.) During the night they issue from their hiding places to feed upon decaying vegetable matter, molds, and other material present in damp soils, although at times the roots of plants and even the green leaves are not eschewed.

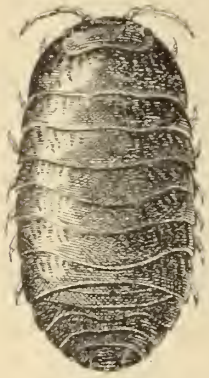

FIG. 5.—The greenhouse pillbug (*Armadillidium vulgare*) extended. Much enlarged. (Original.)

The young are carried about in a pouch, formed by several modified anal plates on the abdomen of the female, until able to shift for themselves. When released by the female the young are similar in appearance to the adults, although much smaller, and are likewise capable of damage. There is probably only one generation annually, the young making their appearance in the spring and requiring one summer to reach maturity.

FIG. 6.—The greenhouse pillbug (*Armadillidium vulgare*) contracted. Much enlarged. (Original.)

The destruction occasioned by sowbugs is due to their attacks on the caps or fruiting bodies of the mushrooms. These they attack while quite small, destroying them or injuring their appearance. They do not, as a rule, attack the mycelium, but eat holes in the young "buttons, which, on the completion of the growth, become much larger and disfigure the product.

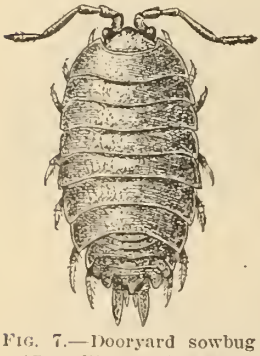

FIG. 7.—Dooryard sowbug (*Porcellio lævis*). Much enlarged. (Original.)

Sowbugs are, more frequently than at first might be thought, carried into the mushroom house in compost which has been allowed to stand outside. The heat of the manure is relished by them, and they collect in numbers, remaining there throughout the growth of the spawn, but becoming injurious with the first growth of the mushrooms. The writer has seen sowbugs collected in manure piles to such an extent that numbers aggregating a pint or more in quantity might have been collected from a shovelful of material.

REMEDIES.

Where the mushroom house is small in extent it is possible materially to reduce the numbers of sowbugs by means of hand picking. The house may be visited at night, when, by the aid of a lantern, numbers of sowbugs may be seen crawling about on the earthen casing of the beds and upon the boards and supports of the benches. These may be destroyed with a small wooden paddle.

It is also possible to secure good results by pouring hot water along the cracks in the boards and in other places where the "bugs" may be concealed by day. This is effective in small establishments, but is somewhat difficult of application in large houses. In such a case, fumigation with hydrocyanic-acid gas is an effective remedy. Treatment with sulphur dioxid[1] is also effective, but this remedy should be applied after the mushroom crop has been harvested and the compost has been removed.

Another method is to cut small pieces of raw potato, plastering the wet surface with Paris green, and laying them about on the beds in the localities affected by the sowbugs. This method is frequently successful in entirely ridding houses of this pest.

CRICKETS.

Among other injurious forms which at times attack mushrooms, certain crickets are reported as eating into the caps of the mushrooms. On the Pacific coast a species known scientifically as *Ceuthophilus pacificus* Thom. has been reported as causing extensive injury to cultivated mushroom beds.

The remedies for crickets in their injurious occurrence are the same as those recommended for sowbugs in a previous section of this circular. Potatoes and carrots may be minced before applying the Paris green, in order to secure a somewhat thicker coat.

GENERAL SUMMARY.

In the construction of mushroom houses care should be taken to make the building as tight as possible and with few outlets. If windows are necessary they should be small and should be screened with fine wire gauze, which forms an excellent prevention against the entrance of both maggots and mites, as previously mentioned. If possible all compost should be steamed before being placed in the house and the temperature should be kept below 55° F., as all insects are more or less dormant at this temperature, and their otherwise

[1] See reprint from Bul. 60, Bur. Ent., U. S. Dept. Agriculture, pp. 139–163, Sulphur Dioxid as an Insecticide.

rapid multiplication is thereby greatly checked, reducing infestation to a minimum. If these recommendations are carefully followed there should be little necessity for the radical measures of fumigation or destruction of the beds.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 17, 1912.*

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